Use of Upweller Systems for Shellfish Nursery Culture

William Mullin, P.O. Box 882, West Barnstable, MA 02668

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Introduction:

The timely availability of shellfish seed has often delayed the growth of small shellfish culture businesses. Small growers are dependant upon commercial hatcheries for seed, and these hatcheries work with factors that are out of their control, such as weather. Thus, seed may not be available in the amount ordered, or on the day ordered, or at the size ordered, even though the hatchery is attempting to provide the delivery.

In 1997 and 1998 larger scale hatchery problems (again out of the hatchery operator's control) caused seed shortages. The hatcheries did an excellent job of providing what they could under adverse circumstances, but the strong demand, coupled with many new growers in the industry caused a seed shortage. This meant that many seed orders were not filled as planned, causing the loss of one growing season to many businesses, and an actual loss of millions of dollars worth of product (that would have been harvested in 2000-2001). To avoid this problem in the future, a network of growers worked together with a commercial hatchery to produce their own seed. Each participating grower built and operated a nursery system for the shellfish seed, which was provided by the hatchery. 100% of the hatchery production went to this network. The development of satellite nursery systems to avoid seed availability problems was the focus of this project.

The mechanics of the project are fully described in the attached research report, complete with diagrams of the methods used (Fig. 1 and 2). The strategy and results are more fully described below.

Upwellers are commonly used to raise small shelfish seed throughout the world. There are many permutations, but the basic idea is that seawater is pumped into a tank and is directed up through a screened container before exiting. The shellfish are grown in this container, on top of the screen, receiving ample water circulation. The shellfish feed upon whatever natural phytoplankton exist in the bay from which the water is pumped.
A long rectangular tank may hold 10-16 individual silos, which can hold thousands of shellfish seed each. The system is an effective way to handle large volumes of small shellfish.

The problem in nursery culture is that the shellfish grow rapidly. Space is a limiting factor, and the problem increases exponentially as the shellfish grow. For a hatchery to upweller millions of seed is a huge undertaking, and the hatchery staff (and space) must then be focused on nursery culture. The creation of satellite upweller sites allowed growers to handle their own seed, and more importantly, freed up the hatchery to focus on production rather than on upwellers. The hatchery produced over 38 million seed in the 1999 season, all of which went towards the growers network. This would not have been possible without a network, as no single individual could handle this quantity in one location.

There were several reasons for moving in this direction.

1. Growers were able to get seed throughout the season, were able to handle it themselves, and were able to plant it out as soon as it became ready. This provides for earlier planting of faster growing seed, and allows each grower to move at their own pace, planting on a weekly basis throughout the summer and into the fall. The same volumes could not be planted all at once in the fall (since planting is limited by suitable tides and weather).

2. There is a substantial cost savings when compared to buying large volumes commercially. Seed averages $20-30/1000, depending upon size. One million seed would cost $20,000-$30,000 to buy, and even then the grower would not know when or if this amount would be delivered.

3. There is control over availability. In some cases seed orders simply were not able to be filled. Seed is ordered in the fall for the following year. There is very strong demand. In the event of some unforseen hatchery problem (which occurs more often than one might think), the order may not be filled as requested. The hatchery has no control over this either, and this is accepted as normal procedure. For example, in the worst case the grower cannot get any seed. Usually, however, the order is simply smaller. An order of 400,000 may actually be 300,000. This translates to 100,000 seed that would have been purchased if it was available, which in turn would have been grown out and sold.

4. There is diversification of risk. The risk factor in growing seed shellfish is substantial. If 100% of the companies seed assets are located in one place, and some type of problem occurs, the entire season is lost. In this way, several satellite nursery locations were built to handle the entire production from one hatchery. In the event of a catastrophe at any one of the locations, this would only account for a portion of the total crop. The hatchery in addition would be able to restock the nursery at any time. This theory was put to the test in 1999, and proved itself in several ways, especially the fact that the hatchery could restock within days if a problem occurred.

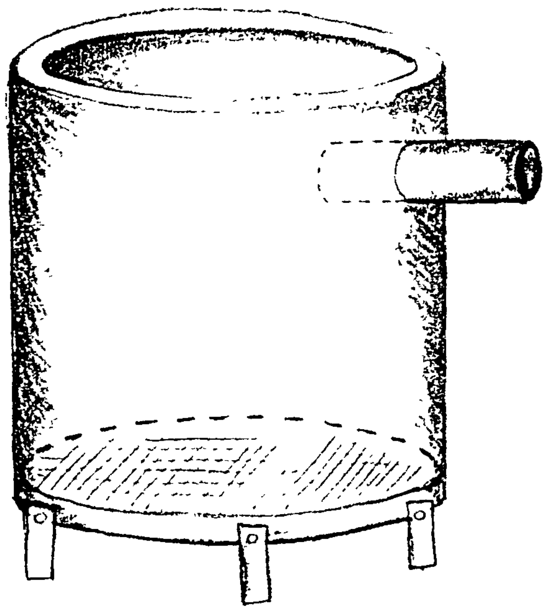

Figure 1a. Upwelling silo. Silo is 20" diameter, with 1.5" PVC outflow. Outflow pipe goes through the plywood tank sidewall (see below) via a PVC sleeve coupling. Outflow pipe is pressure fit only, and is pulled out of the coupling to clean the silo. The entire silo can be lifted out of the tank for cleaning or thinning. Bottom screen is 750 micron; window screen is used for larger seed. Legs are 2" PVC or wood, attached to silo with screws.

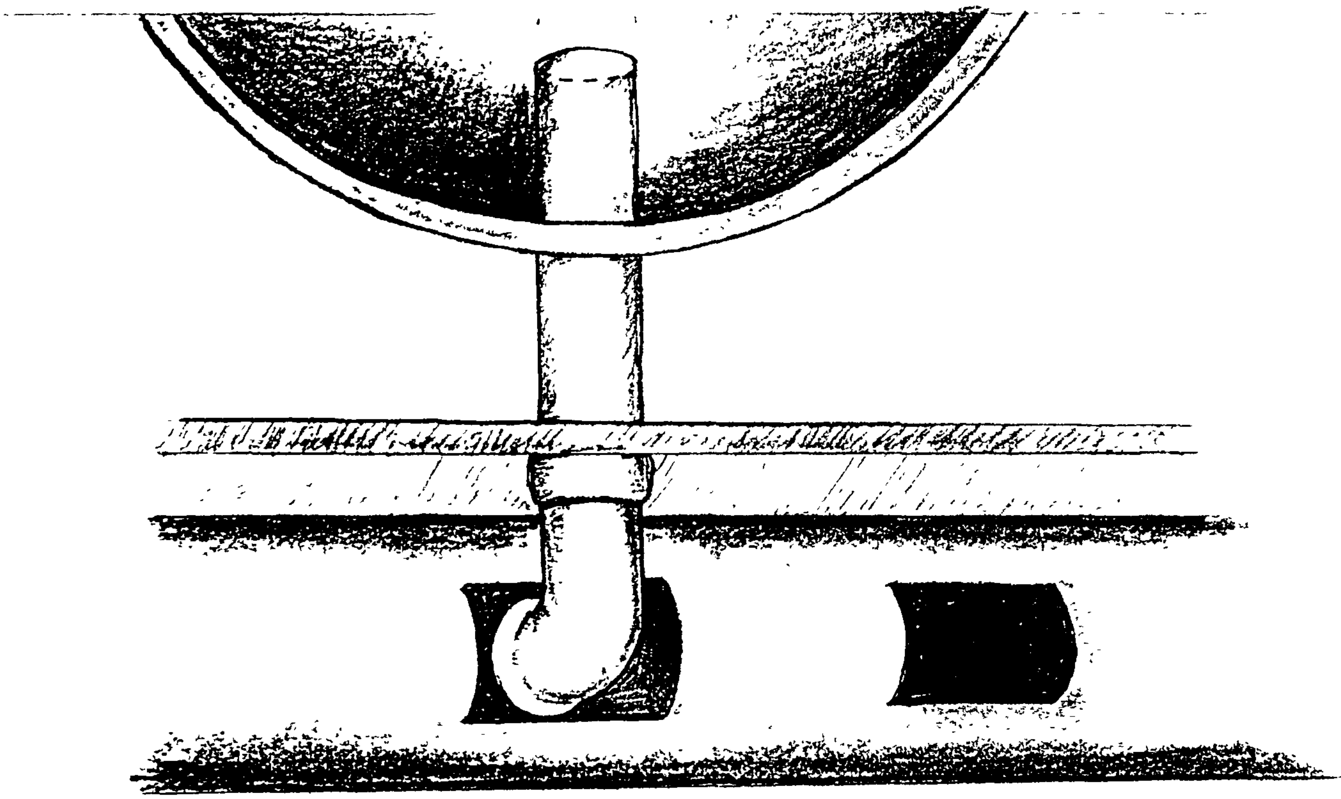

Figure 1b: Expansion view of outflow pipe through tank sidewall. 1.5"PVC outflow pipe leaves upweller silo (Fig 1a), through plywood tank sidewall attaching to a PVC sleeve coupling (glued into sidewall). Outflow/sleeve connection is pressure fit only, as these are separated for cleaning. Water exits to 90 PVC elbow drain, into gutter on exterior side of tank. Gutter is 6" PVC with rectangular holes cut for each elbow drain (see Figure 2).

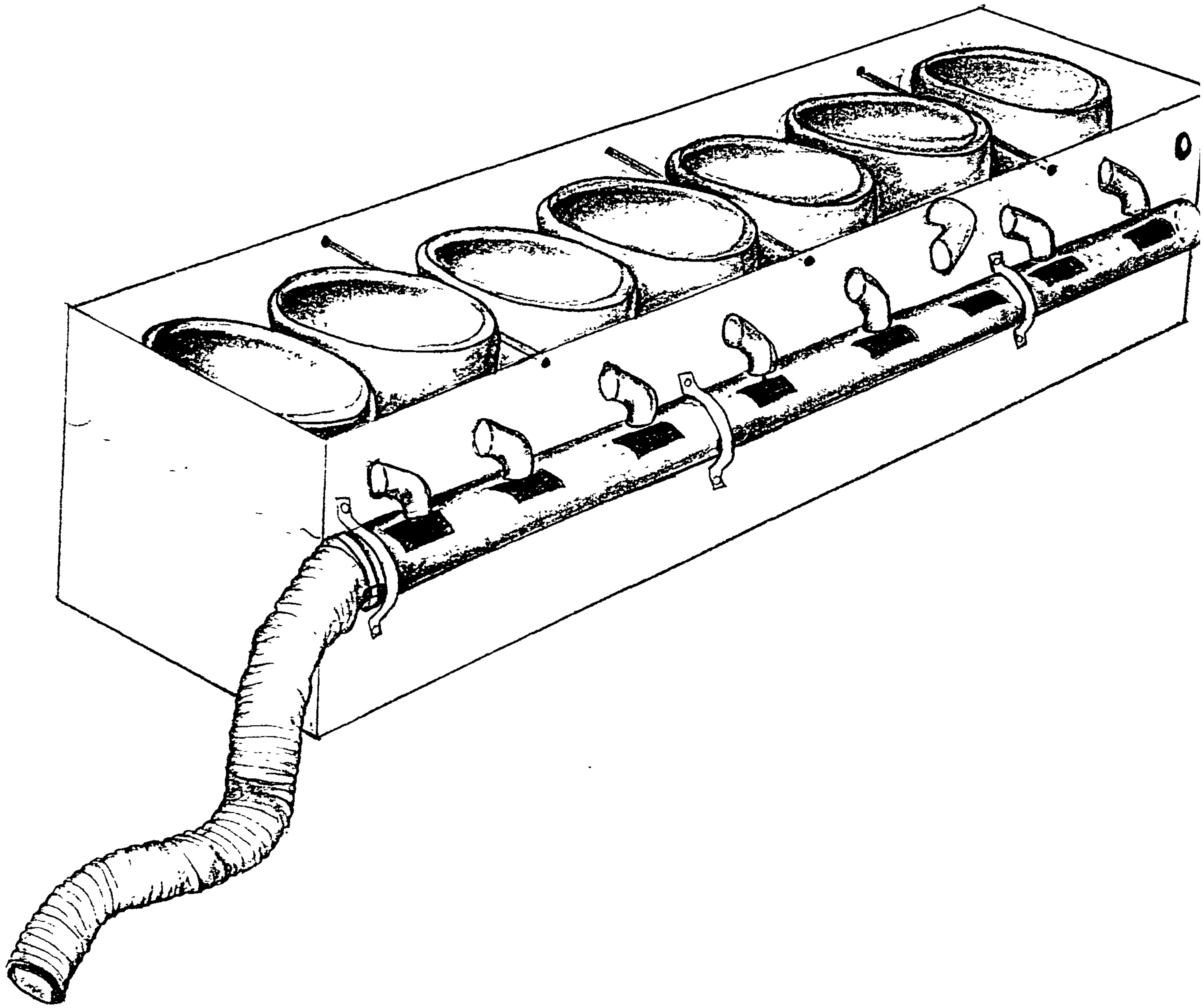

Figure 2. Complete upweller tank, showing silos, PVC elbow drains, and external gutter (6" PVC with holes, attached to sidewall with straps). Threaded reinforcing bar used every 4' to brace sidewalls. Gutter attaches to 6" flexible hose, which returns water directly to bay or marsh. Intake line not shown.

The participants developed four satellite upweller nursery locations (land based facilities using pumped water), which handled the very small seed as it came out of the hatchery. This seed is in the 750 micron to 1 mm range. The seed was then moved licensed growing areas as soon as it was large enough to get out of the nursery. When space became available in the nursery system, it was quickly filled by new seed from the hatchery. Note that each upweller requires attention 7 days/week, and that the effort involved in managing them is intensive. Careless operation usually results in stunted growth and often mortality, and is not an option in this context. Thinning alone is a major undertaking, and must be done regularly to ensure continued growth.

Results/Cost Analysis:

The hatchery produced about 38 million seed in 1999. This is astounding for a small facility, but was made possible because the hatchery did not have to spend effort or space on the nursery culture phase. Seed was shipped to the satellite locations almost immediately. In contrast, similar sized facilities attempting to do everything from A-Z may produce 3 to 5 million animals. The nursery stage is not only a lot of work, but the animals require increasing amounts of space as well as food.

At the end of the season, approximately 9 million seed were successfully moved through the nursery phase in the upweller systems. This was far fewer than estimated, given previous success rates. This high mortality was due to a massive die-off that we believe was caused by zinc toxicity. A metal bridge immediately adjacent to the site was being sandblasted, primed, and repainted during the mortality, which occurred in mid-summer. Another upweller facility nearby was also affected. Initially there was one major loss but the survivors went to on recover. A second 100% loss took about 8 million seed. This disaster proved the point of diversifying the risk element. We had no control over the painting activity or the mortality. There was no mortality at any of the other sites during this time, which continued to function well. Finally, the hatchery was able to restock the site almost immediately. In any other context, a total loss of seed in mid-summer would mean the end of the season. After this disappointing loss, the project would still turn out to be successful because of the ability to restock.

The value of 9 million seed (field plant) is about $30/1000. The value of the product grown in 1999 is about $270,000 (seed value). If the participants had wanted to buy this amount of seed, it would have cost $270,000, if it were available. This is the key item, since this quantity of seed generally is simply not available. The participants also did not think that this was a good investment.

If grown out to harvest, the value as littleneck clams is $570,000, if using a conservative 33% survival rate, and a wholesale price of $0.19. Our current survival rate is well above 50% however, and pricing ranges from $0.19-0.22 (actual value will most likely be over $1 million). At the same time, it is impossible to predict survival until the crop is actually harvested and sold, so conservative figures have been used.

The project participants spent over $100,000 in developing this effort. However, many of these costs are one time set-up costs, which will be amortized over the next 2-3 years. Some of the larger equipment items will be amortized over 5 years. Once the upweller systems are built, in place, and operational, maintenance costs are minimal. Staff also are trained, and familiar with the requirements of running the systems, and therefore, productivity should be greater.

For this project, in 1999, the cost/benefit calculations were affected by both the major mortality (about 10 million field plant seed, which would have been worth almost $300,000), and the initial set up costs (almost $50,000), which are one time costs that are not related to operations. Even so, the project more than made up for its cost by October ($270,000 worth of seed, which, even if you wanted to spend this much on 9 million seed, it would not be available. The ability to have access to these volumes are a key ingredient to the long term success of the business). The estimated value of this crop is close to $1 million, assuming consistant survival rates experienced in previous years.

In the upcoming year, the same approach will be used, except that total production/operations costs will only be about $50,000, and the total production is anticipated to be greater. Even at the same production rate (9 million, or, about 25% survival) this is worthwhile. The sum of three year's production costs is approximately $200,000, in which time the production from year one ($270,000 in seed, and a much larger value as littleneck product) more than covered three year's expenses. Any level of production in the following two seasons is cost effective, given the same operating cost parameters.

In terms of the grower's network involved here, the project was a definite success. The total mortality at the one site was a setback, but proved the value of this approach. Such a loss could have ended the whole season in another situation. The success of the project in spite of the loss was in fact encouraging. Although it is speculative thinking to try to predict the actual value of product to be harvested two years from now, it is clear that the project was worth more than double its cost (for the 1999 year). Our initial assumption on evaluation here was that evaluation would be based on the commercial wholesale price for the amount of seed produced.

From an industry wide perspective, the results are even more far reaching. A hatchery does not have to be big or expensive. A small hatchery can provide for many growers if they can handle the nursery phase of culture in upwellers. Since the construction of a large multi-million dollar hatchery facility is unlikely anywhere in the region (and not cost effective either), this smaller scale satellite approach is an effective way to address the seed availability problem. A number of smaller hatcheries, as needed, is a cost effective approach to addressing seed availability, as long as the hatchery can focus on seed production rather than on nursery culture.

Changes in project approach:

The project was completed with only minor changes. In all, the participants spent slightly more on the project than they had anticipated. These costs have been absorbed by the participating companies, and are longer term capital improvements to each facility. The value of an upweller system at each site became if anything, more obvious, if that is at all possible, and additional upweller construction is in progress now (separate from this project). This is in part due to the fact that the approach was still viable in spite of the massive mortality experienced.
As the supplies and operations costs were above that anticipated, the final budget was amended to move the remainder of the travel line item into supplies/operations, as discussed with the grant administrator, Craig Richov, on 11/18/99. These travel costs were also greater than expected, but were absorbed by the participants.

Future developments:

The project demonstrated a viable way to produce large numbers of seed, but production is now being modified to reduce operating costs, and/or to increase production in areas formerly deemed unsuitable for production. One major development is the construction of an upwelling rafting facility, using a floating work platform with landbased power. The floating system does not require any space onshore, which is usually at a premium, as long as electricity can be run to the raft area. Floating upwellers also reduce energy costs considerably, since high volume pumps can be used (the total lift required to run the system is only a few inches compared to several feet for a landbased system). Many land based systems require a lift capacity of 10-20', considerably reducing flow volumes (as well as increasing electrical costs).

Conclusions:

Satellite shellfish nurseries, using upwelling tanks, are an economical and effective way to handle large volumes of seed, which otherwise would not be accessible to small growers. Upweller construction is simple, and can be done during the winter (schematics provided in Figures 1 and 2). Operation is labor intensive, and therefore expensive, but is worthwhile in terms of quantity and quality of seed produced. The value of seed production in the first year exceeded the cost of three years operations. There are several additional significant but almost intangible benefits in addition to having the seed supply, which are important to the long term health of the business. These are:

a) access to the seed throughout the entire growing season, allowing field planting throughout the season as soon as the seed reaches plantable size,
b) opportunity for experimentation on small batches of seed to try out innovative growout methods at a low cost,
c) control over the supply, and the ability to restock in the event of a disaster, and
d) access to a volume that otherwise would not exist at all.

For example, none of the participants would purchase 9 million field plant seed, and therefore could not plant this volume under any other situation. These volumes, however, are the key to success, since mortalities can and do occur, and the risk element is high. All participants are expanding their nursery capacity after this season, given the encouraging results. As a direct result there will be an anticipated $1 million/year in additional wholesale shellfish revenue (landed value) that otherwise would not exist. These funds can in turn be reinvested in research and development, an area which is sorely needed if the shellfish culture industry is ever to move into a more mechanized and efficient environment.

INVOICE, December 1, 1999 (final).

In account with: Wm Mullin, P.O. Box 882, W. Barnstable, MA 02668

	Dept.FA	Match	Total
Labor	11,252.75	19,645.00	30,897.75
Supplies/Operations	10,235.76	654.36	10,890.12
Equipment	0	0	0
Travel	0.00	1,748.38	1,748.38
Postage	195.00	0	195.00
Phone/Fax	658.00	512.62	1,170.62
Total	22,341.51	22,560.36	44,901.87
Total to date (7/1/99 invoice)	15,058.30	42,981.82	58,040.12
Total Project	37,399.81	65,552.18	102,941.99